CSC 261/461
Database Systems

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Relational Algebra

Operations

- Unary Relational Operations
  - SELECT (symbol: σ (sigma))
  - PROJECT (symbol: π (pi))
  - RENAME (symbol: ρ (rho))
- Relational Algebra Operations From Set Theory
  - UNION ($\bigcup$), INTERSECTION ($\bigcap$), DIFFERENCE ($-$)
  - CARTESIAN PRODUCT (X)

Operations of RA

Selection

The SELECT operation σ is used to select a subset of the tuples from a relation based on a selection condition.

- The selection condition acts as a filter
  - Keeps only those tuples that satisfy the qualifying condition
  - Tuples satisfying the condition are selected whereas the other tuples are discarded (filtered out)

Operations of RA

Selection

- In general, the select operation is denoted by $\sigma_{<selection\ condition>}(R)$
  - the selection condition is a Boolean (conditional) expression specified on the attributes of relation R
  - tuples that make the condition true appear in the result of the operation
  - tuples that make the condition false are discarded from the result of the operation

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Example

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5

What is $\sigma_{Dno=5 \ AND \ Sex='F'}(EMPLOYEE)$?

Commutativity

Selection Properties

- $\sigma_{<selection\ condition>}(R)$ produces a relation with same attributes as R
- σ is `commutative`
- A cascade of σ operations may be replaced by a single selection with a conjunction of all the conditions.
- The number of tuples in the result of a σ is $\leq$ the number of tuples in the input relation R

Operations of RA

Projection

- PROJECT Operation is denoted by π
- π keeps certain attributes from a relation and discards the others.
- it creates a vertical partitioning
  - Only specified attributes are kept in each tuple
  - other attributes in each tuple are discarded

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Example

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
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Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

Lname	Fname	Salary
Smith	John	30000
Wong	Franklin	40000
Zelaya	Alicia	25000
Wallace	Jennifer	43000
Narayan	Ramesh	38000
English	Joyce	25000
Jabbar	Ahmad	25000
Borg	James	55000

Sex	Salary
M	30000
M	40000
F	25000
F	43000
M	38000
M	25000
M	55000

Operations of RA

Projection

The general form of the project operation is

$$\pi_{<attribute\ list>}(R)$$

- π (pi) is the symbol used to represent the project operation
- What is the degree of the resulting relation?
- duplicates are removed (set)
- What is the number of tuples in the resulting relation?

Operations of RA

Projection

PROJECT Operation Properties

- The number of tuples in the result of projection $\pi_{<list>}(R)$ is always less or equal to the number of tuples in R
  - If the list of attributes includes a key of R, then the number of tuples in the result of PROJECT is equal to the number of tuples in R
  - Is π commutative?

RA Expressions

We may want to apply several relational algebra operations one after the other.

- Either we can write the operations as a single relational algebra expression by nesting the operations
- We can apply one operation at a time and create intermediate result relations.
- In the latter case, we must give names to the relations that hold the intermediate results.

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Operations of RA

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
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James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

Fname	Lname	Salary
John	Smith	30000
Franklin	Wong	40000
Ramesh	Narayan	38000
Joyce	English	25000

Operations of RA

Using temporary relations

$TEMP \leftarrow \sigma_{Dno=5}(EMPLOYEE$

$R(First\_name, Last\_name, Salary) \leftarrow \pi_{Fname,Lname,Salary}(TEMP)$

TEMP

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston,TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston,TX	M	40000	888665555	5
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble,TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5

R

First_name	Last_name	Salary
John	Smith	30000
Franklin	Wong	40000
Ramesh	Narayan	38000
Joyce	English	25000

Operations of RA

RENAME

- The RENAME operator is denoted by ρ (rho)
- In some cases, we may want to rename the attributes of a relation or the relation name or both
- Useful when a query requires multiple operations
- Necessary in some cases (see JOIN)

Operations of RA

RENAME

- The general ρ operation can be expressed by any of the following forms:
  - $\rho_{S(B1,B2,\ldots,Bn)}(R)$ changes:
    - the relation name to S, and
    - the column (attribute) names to B1, B2, ..., Bn
  - $\rho_S(R)$ changes:
    - the relation name only to S
  - $\rho_{(B1,B2,\ldots,Bn)}(R)$ changes:
    - the column (attribute) names only to B1, B2, ..., Bn

Operations RA

UNION

- Binary operation, denoted by $\bigcup$
- The result of $R \bigcup S$, is a relation that includes all tuples that are either in R or in S or in both R and S
- Duplicate tuples are eliminated
- The two operand relations R and S must be "type compatible"
  - R and S must have same number of attributes
  - Each pair of corresponding attributes must be type compatible

Operations of RA

INTERSECTION

- INTERSECTION is denoted by $\cap$
- The result of the operation R $\cap$ S, is a relation that includes all tuples that are in both R and S
- The attribute names in the result will be the same as the attribute names in R
- The two operand relations R and S must be "type compatible"

Operations of RA

SET DIFFERENCE

- SET DIFFERENCE (also called MINUS or EXCEPT) is denoted by $-$
- The result of R $-$ S, is a relation that includes all tuples that are in R but not in S
- The attribute names in the result will be the same as the attribute names in R
- The two operand relations R and S must be "type compatible"